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Sunspot data collection of Specola Solare Ticinese in Locarno

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Abstract. Sunspot observations and counting are carried out at the Specola Solare Ticinese in Locarno since 1957 when it was built as an external observing station of the Zurich observatory. When in 1980 the data center responsibility was transferred from ETH Zurich to the Royal Observatory of Belgium in Brussels, the observations in Locarno continued and Specola Solare Ticinese got the role of pilot station. The data collected at Specola cover now the last 6 solar cycles.

The aim of this presentation is to discuss and give an overview about the Specola data collection, the applied counting method and the future archiving projects. The latter includes the publication of all data and drawings in digital form in collaboration with the ETH Zurich University Archives, where a parallel digitization project is ongoing for the document of the former Swiss Federal Observatory in Zurich collected since the time of Rudolph Wolf.

Keywords. Sun: activity, Sun: evolution, sunspots

1. Historical overview

The long tradition in Switzerland of systematic observations and counting of sunspots was started by Rudolf Wolf in 1847 (Friedli, 2016), first in Bern and then in Zurich, where in 1855 he was nominated professor for astronomy both at the Zurich University and at the Swiss Federal Institute of Technology (ETH-Zurich). To study the solar cycle, that was discovered by Samuel Schwabe few years before, Wolf introduced the notorious empirical index well know as *Wolf number* or as *Zurich relative sunspot number*, which is defined as:

$$R = k(10g + s) \tag{1.1}$$

where g is the number of sunspot groups, s the number of single sunspots and k a normalization factor which depends on the observer. Being Wolf the reference, his observations were originally normalized with the factor $k = 1$. The sunspot observations and the determination of the daily value of the Zurich relative sunspot number continued at the Swiss Federal Observatory in Zurich with Wolf's successors Alfred Wolfer, William Brunner and Max Waldmeier, who had a normalizing factor $k = 0.6$ (Clette *et al.*, 2014).

In 1936 the retired engineer Karl Rapp, grounder of BMW, moved to Locarno in Southern Switzerland and started regular observations of sunspots, collaborating with Brunner and Waldmeier. The favorable weather conditions in Locarno allowed often to fill the gaps of data when in Zurich clouds didn't allow to observe. Based on this positive experience, Waldmeier managed in the International Geophysical Year (1957) to ground an external observing station in Locarno, that became the Specola Solare Ticinese (Cortesi *et al.*,

2016). Sergio Cortesi and Araldo Pittini were hired as Waldmeier's assistants, in order to carry out observations at the Specola.

After Waldmeier's retirement in 1979, ETH-Zurich decided to abandon the research activity related to the sunspot counting. The Royal Observatory of Belgium in Brussels agreed to take over this service. In January 1981, the new world data center in Brussels, previously called SIDC and now SILSO, took over the responsibility to determine the daily Wolf number, from then on called *international sunspot number* (SSN) (Stenflo, 2016). At that point, thanks to experience gained with Waldmeier, Specola Solare Ticinese became the pilot station with the role to guarantee the long term stability of the SSN. Observations continued under the direction of Cortesi, that acted as main observer. After some years of training, in 2011, Marco Cagnotti became the new main observer at Specola.

2. The sunspot drawings of the Specola Solare Ticinese

Observations in Locarno are obtained with a Coudé-Zeiss refractor with an aperture of 15 cm. This is diaphragmed to 8 cm, in order to obtain a better visual contrast. The refractor projects a solar mirrored image with a diameter of 25 cm on a metallic plate where a paper sheet is fixed, where the observer can draw the sunspots with a pencil (Fig. 1). Originally, sunspot counting is done following the rules taught by Waldmeier to the Specola observers (Waldmeier, 1948), where sunspots are weighted according to their size. For instance, small point-like sunspots are counted as 1, larger sunspots as 2, a sunspot with penumbra of normal size is counted as 3, while a very large sunspot with penumbra is counted as 5.

In 2012, it has been proposed to apply in parallel to the original counting method, an unweighted counting where each sunspot is counted as 1 independently of its size. This allowed comparison studies of the two methods (Svalgaard *et al.*, 2017) that were used in recent works aiming at a better homogenization of the SSN in the past. In particular the results of this study led to a better understanding of the "Waldmeier jump" occurred around 1947 when Waldmeier became the new director of the Swiss Federal Observatory in Zurich instead of Brunner. These studies were taken into account in the revision of the SSN introduced by SILSO on July 2015 by SILSO (Clette & Lefèvre, 2016). One of the decisions that was taken for this revision was to use the unweighted counting of Locarno as the new reference†. Since August 2014 both weighted and unweighted countings of the Specola, are reported officially on the sunspot drawings and communicated to SILSO. Meanwhile, for further studies, we started to determine the unweighted counting from the past drawings of the Specola. This work is still in progress.

3. Sunspot data and drawings archiving

The digitized Sunspot drawings of the Specola Solare Ticinese are published daily on the WEB at the URL `http://specola.ch/e/drawings`. At the same address one can find the archive that includes all digitized drawings made since 1981, when the Specola became independent from ETH-Zurich. The drawings made at Specola from 1957 to 1980 are stored in the ETH Zurich University Archives at the ETH-library, together with all the material collected by the former Swiss Federal Observatory in Zurich.

† Another important change in the SSN revision adopted by SILSO in July 2015 was to take Wolfer as reference, instead of Wolf for the normalization factor $k = 1$ present in equation 1.1. (Clette & Lefèvre, 2016)

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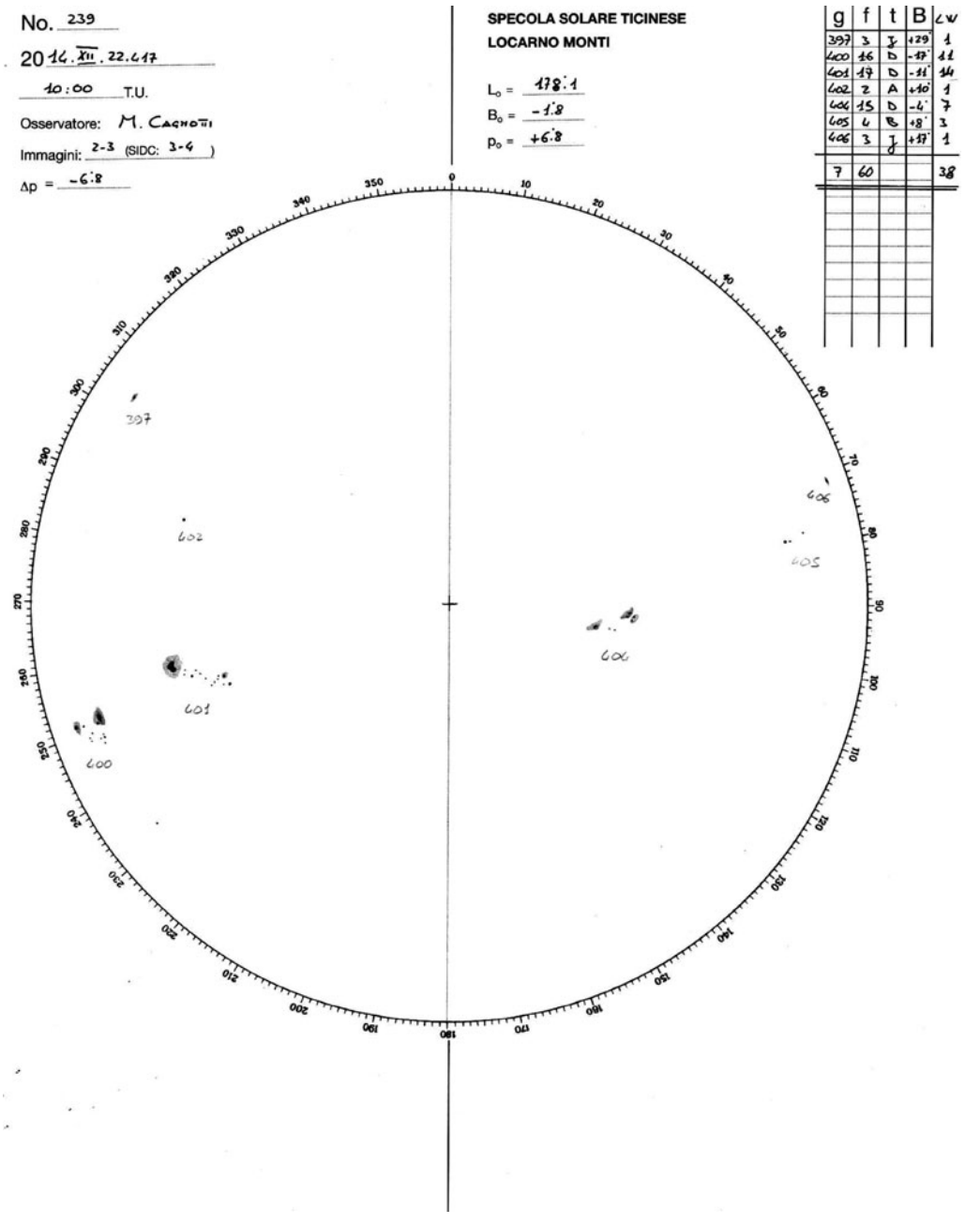

Figure 1. Example of a sunspot drawing obtained at Specola Solare Ticinese in Locarno. The solar image is mirrored. In the top-right table, for each sunspot group, it is reported the serial number, the weighted counting of the sunspots, the Zurich classification and the unweighted counting.

For the safe long term preservation of the sunspot drawings and data collected in Locarno, Specola Solare Ticinese and ETH Zurich University Archives are starting a project together. This foresees that all the drawings, including the ones made previously than 1981, will be professionally digitized and made openly accessible through the

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E-manuscripta digital platform for manuscript material from Swiss libraries and archives accessible at `http://www.e-manuscripta.ch`. All drawings will have their own digital object identifier (DOI). The digitization project of the Specola drawings will complement a parallel project done by the ETH Zurich University Archives, in which the full sunspot drawings collection of the former Swiss Federal Observatory in Zurich is being digitized and made available on the same digital platform E-manuscripta.

In addition, according to the project, it is foreseen that all the Specola drawings made until now will be safely stored at the ETH Zurich University Archives. Furthermore in the next years it is planned to prepare a digital sunspot group database that will be published with open access. The database will contain information for each sunspot group about observing date, observer, image quality, group ID serial number, Zurich classification, latitude, original weighted counting. It is also foreseen to perform a post-unweighted counting and to add this information to the database. Giving open access, we hope that the database will be a useful data source for all researchers for further studies of the data series obtained at Specola.

4. Acknowledgments

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